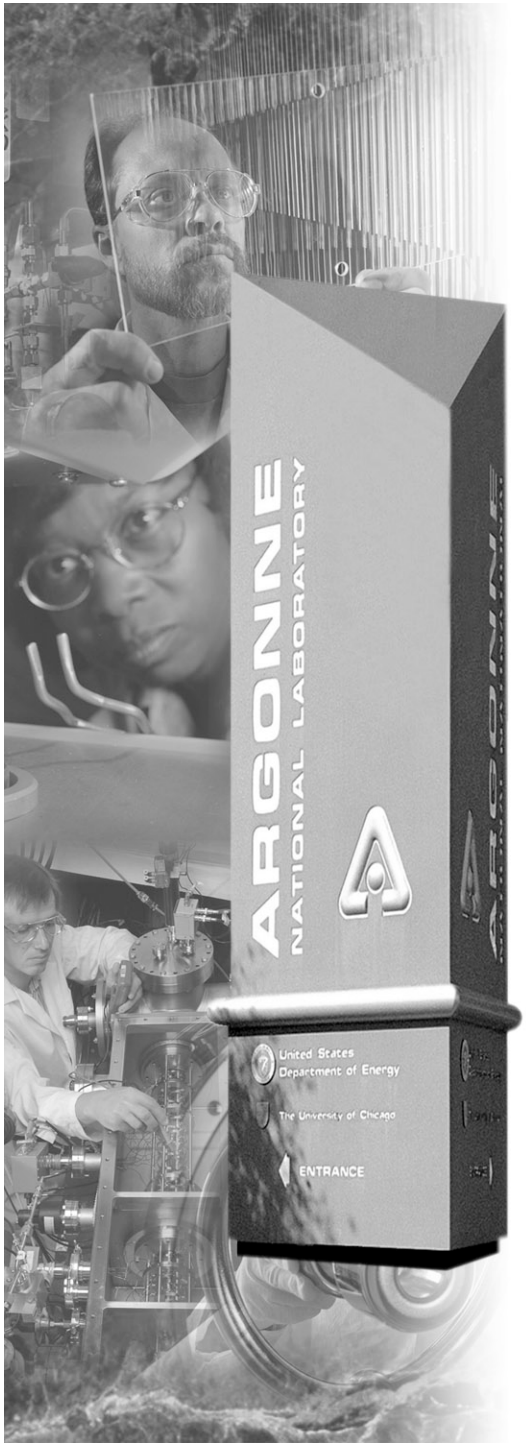

SNF Treatment at ANL-W

James Werner

National SNF Technical Exchange Meeting
Las Vegas, NV
***October 20*, 2004**

Argonne National Laboratory

Office of Science
U.S. Department of Energy

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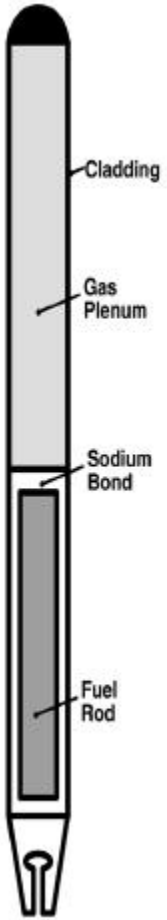
Outline

- **Background**
- **Tansuranic Recovery Experiments**
- **Blanket Fuel Disposition Alternatives**
- **Electrorefiner Improvements**
- **Waste Development efforts**
- **Summary**

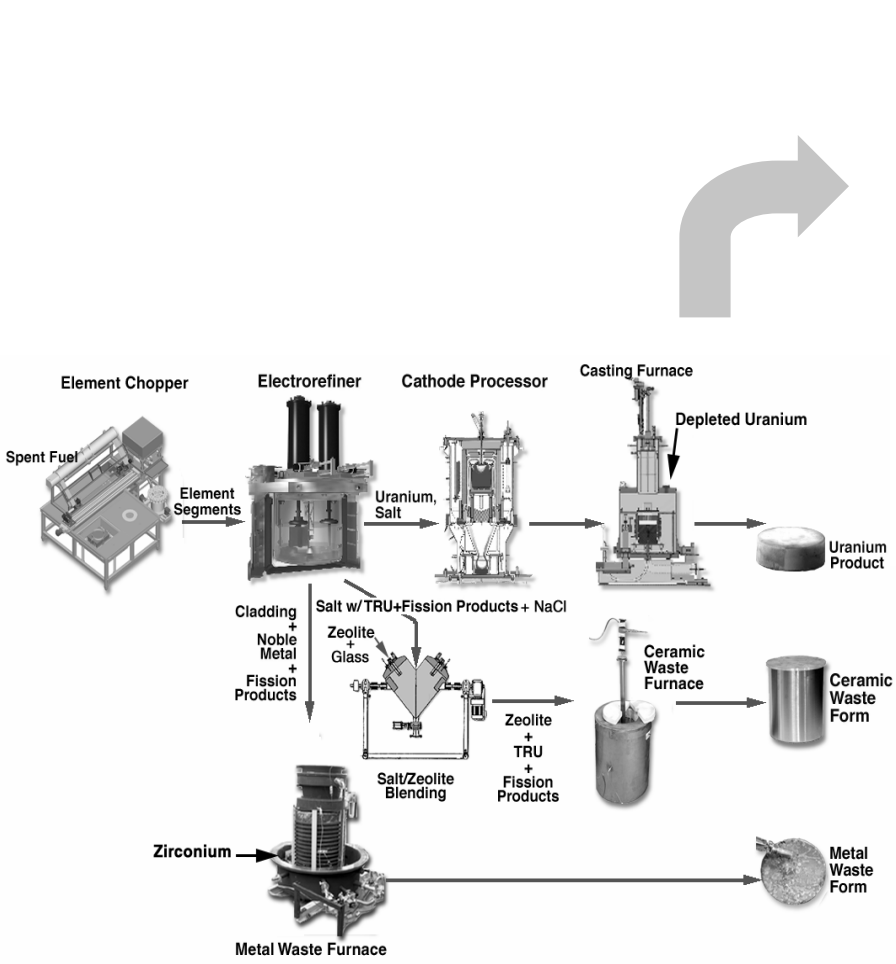
EBR-II Spent Fuel Treatment

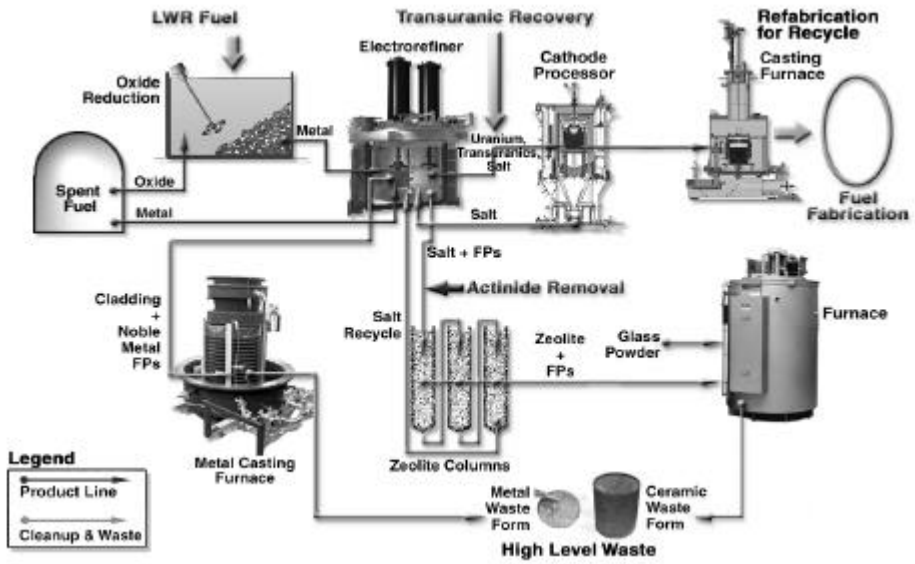
- **EBR-II Spent Fuel Treatment Program has been underway since September 2000, following completion of a three-year demonstration, an EIS,an independent cost study, and a non-proliferation assessment.**
- **EBR-II driver and blanket fuels contain bonded sodium (a reactive metal).**
- **EBR-II driver fuel is HEU, and the blanket fuel contains approximately 1% plutonium.**



Fuel Type	EBR-II Driver at ANL-West (kg)	EBR-II Driver at INTEC (kg)	FFTF Fuel (kg)	Total (kg)
Driver Fuel	700	2,000	250	2,950
Blanket Fuel	21,800	0	0	21,800
Total	22,500	2,000	250	24,750

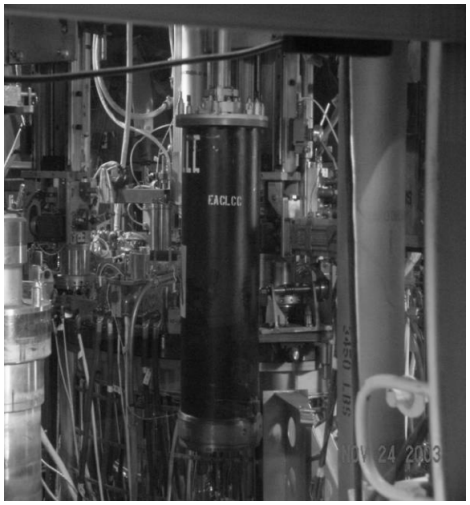
EBR-II Spent Fuel Treatment Program





Treatment of EBR-II fuel is being used to demonstrate key components of the pyrochemical fuel cycle.

Technology Development Activities

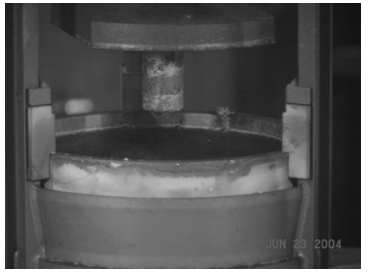


- **Fuel treatment operations are being used to support technology development activities.**
- **In FY03, treatment of blanket fuel was the focus to support transuranic recovery tests starting in FY04.**
- **Treatment of driver fuel has been the focus in FY04, with various experiments included during standard processing.**

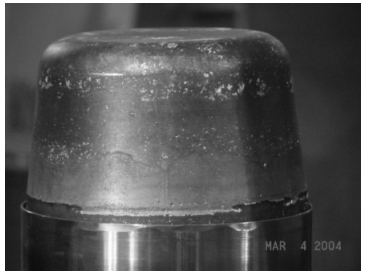
TRU Recovery Experiments

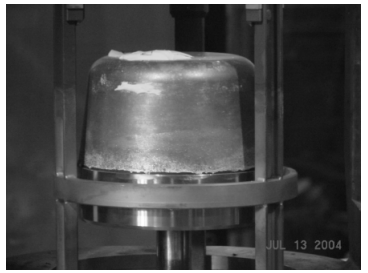
- **Conclusions**
  - First engineering-scale Liquid Cadmium Cathode (LCC) test successfully recovered >1 kg TRU
  - Second engineering-scale LCC experiment performed at lower Pu:U ratio in salt
- **Future work**
  - Optimize LCC operation
  - Assess recovery of actinides and rare-earths

Liquid Cadmium Cathode Ingots in Crucible →



Liquid Cadmium Cathode Ingots (harvested) →



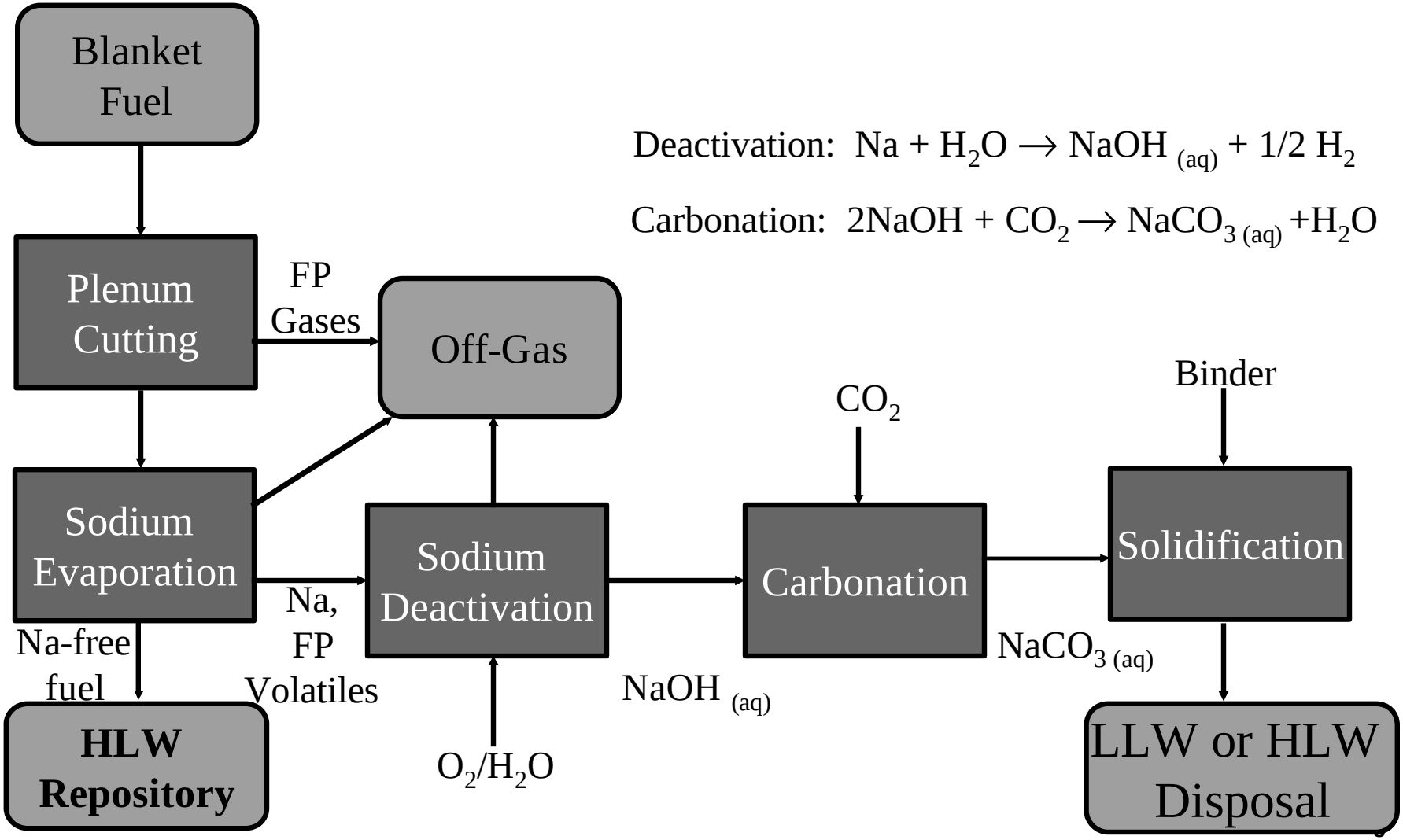


Development of Blanket Alternatives

Options considered:

- **Sodium distillation using the Melt Drain Evaporate Carbonate (MEDEC) process.**
- **Sodium treatment followed by fuel melting.**
- **High throughput electrorefining.**
  - Planar electrode electrorefiner development
  - Next generation anode basket

Melt Drain Evaporate Carbonate (MEDEC) - Flow Sheet

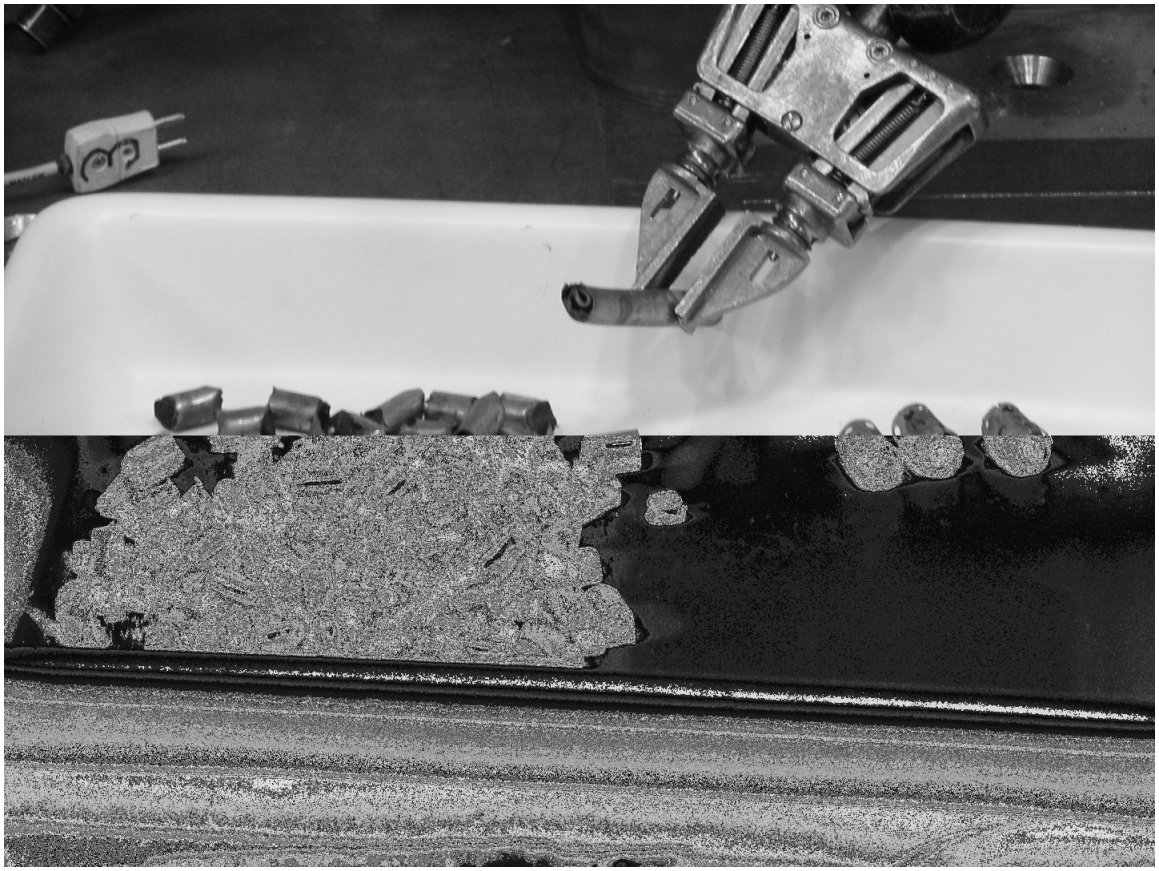


MEDEC Option Work Scope FY2004

- **Evaluate sodium distillation equipment requirements.**
- **Assess the feasibility of and prepare test plan for high burn-up fuels tests.**
  - Extent of sodium removal
  - Co-transport of cesium
- **Evaluate safeguards and security issues associated with high purity plutonium in fuel.**
- **Identify outstanding technical issues for implementation of MEDEC technology.**
  - Quality assurance approach
  - Facility modifications
  - Feasibility of hot cell implementation
  - Waste classification

High Burn-up Fuel Test Summary

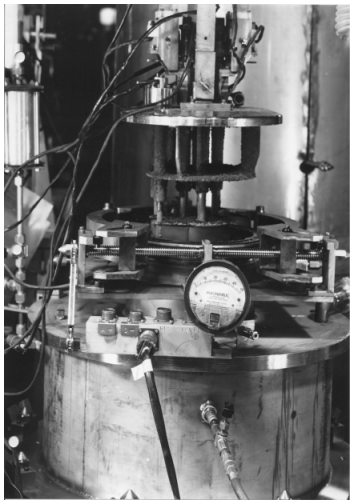
- **Process Conditions**
  - 650 °C
  - <200 mTorr
- **Residual Sodium**
  - Test 1 – 0.68mg
  - Test 2 – 0.09mg
  - Test 3 – 7.27mg
- **Minimum removal achieved: 99.5%**
- **Cesium inventory**
  - 7-11 Ci

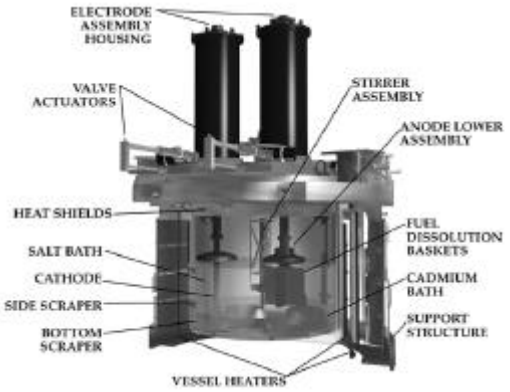


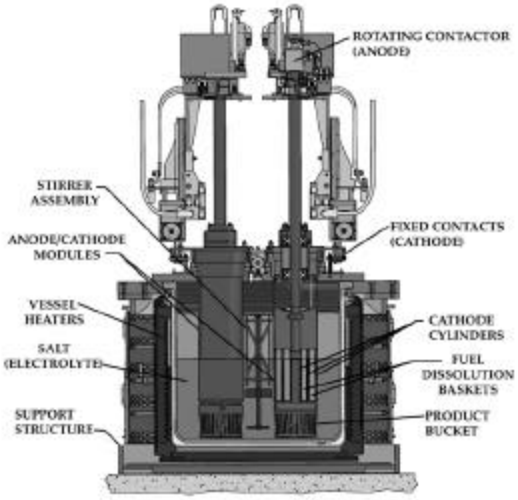
* Complete analysis is not yet available.

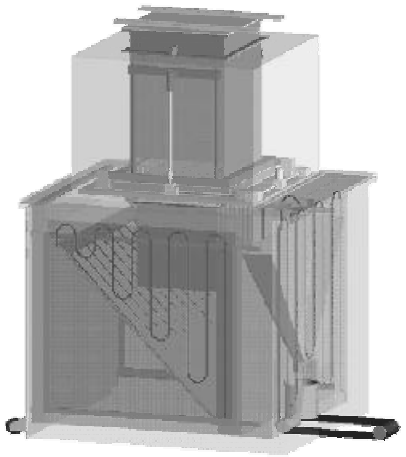
Hot Cell Electrorefiner Scale up

- Throughout development of electrometallurgical treatment, electrorefining technology has been scaled significantly for hot cell application.
- First hot cell electrorefiner has a current capacity of 3.5 amps.
- Mark IV electrorefiner has a current capacity of 200 amps.
- Mark V electrorefiner has a current capacity of 2400 amps.
- Technology has been scale in cell by a factor of almost 700.
- Design has been developed for a system with a capacity of 10,000 amps.



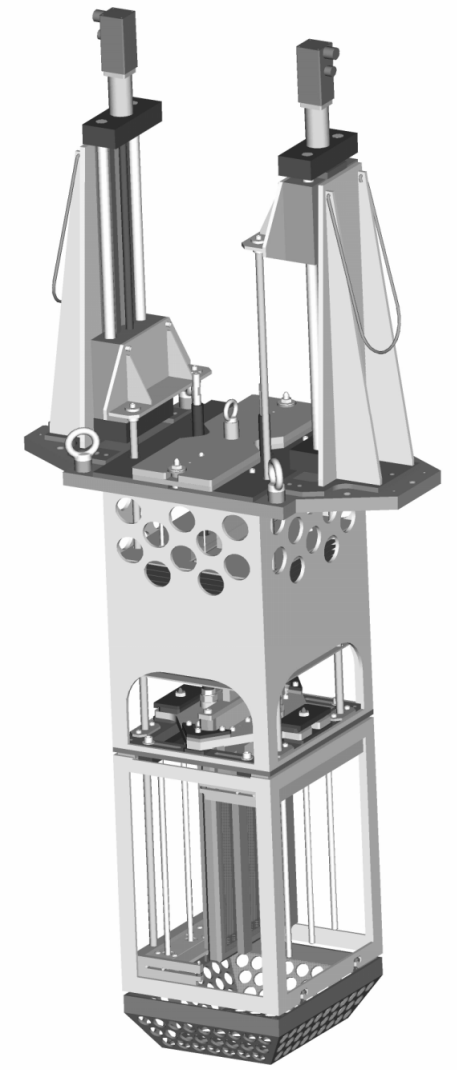






Advances in Electrorefiner Throughput

- **Planar Electrode Electrorefiner (PEER) is being designed to allow higher fuel processing throughput to be achieved.**
  - Design incorporates stationary planar electrodes rather than the traditionally used circular, rotating electrodes.
  - Heavy metal product is collected at the bottom of the ER where it may removed continuously.
- **Prototype PEER has been fabricated and is being installed in J-118 glovebox**



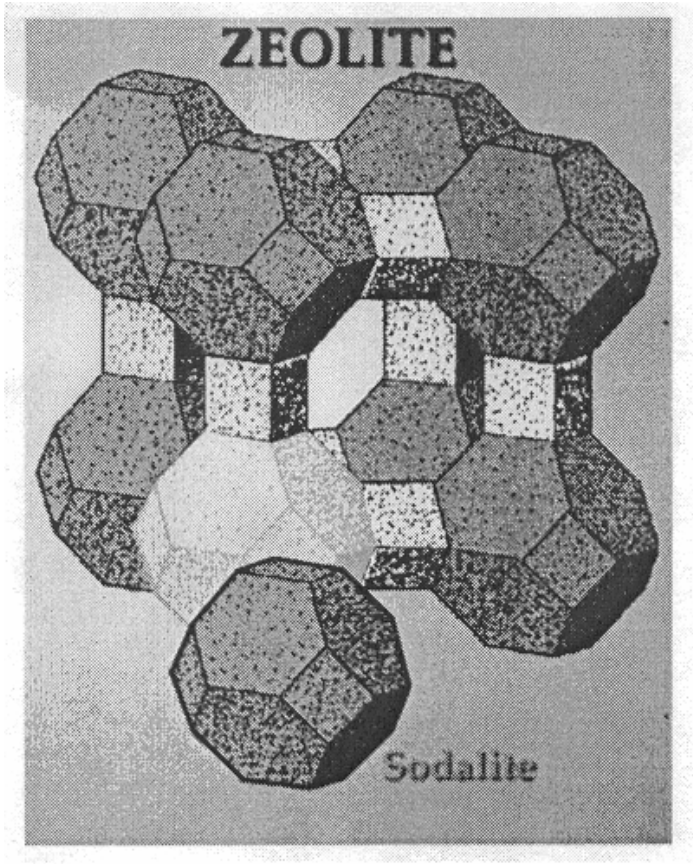
Cathode Material Development

- **Goal is to increase Mk-V electrorefiner throughput.**
- **Approach**
  - Develop and test cathode and coating materials to which uranium deposits do not adhere
  - Study the experimental conditions under which uranium deposit morphology is either very dendritic or is readily released from the cathode surface.
- **Target cathode and coating materials**
  - Glassy carbon
  - TiN, ZrN, TiAlN, W, and Ta
- **Test Approaches**
  - Cold LiCl-KCl-UCl_3 salt
  - Varying UCl_3 concentrations, 0.25 to 4.0 wt% uranium
  - Electrochemical measurements and electrorefining tests

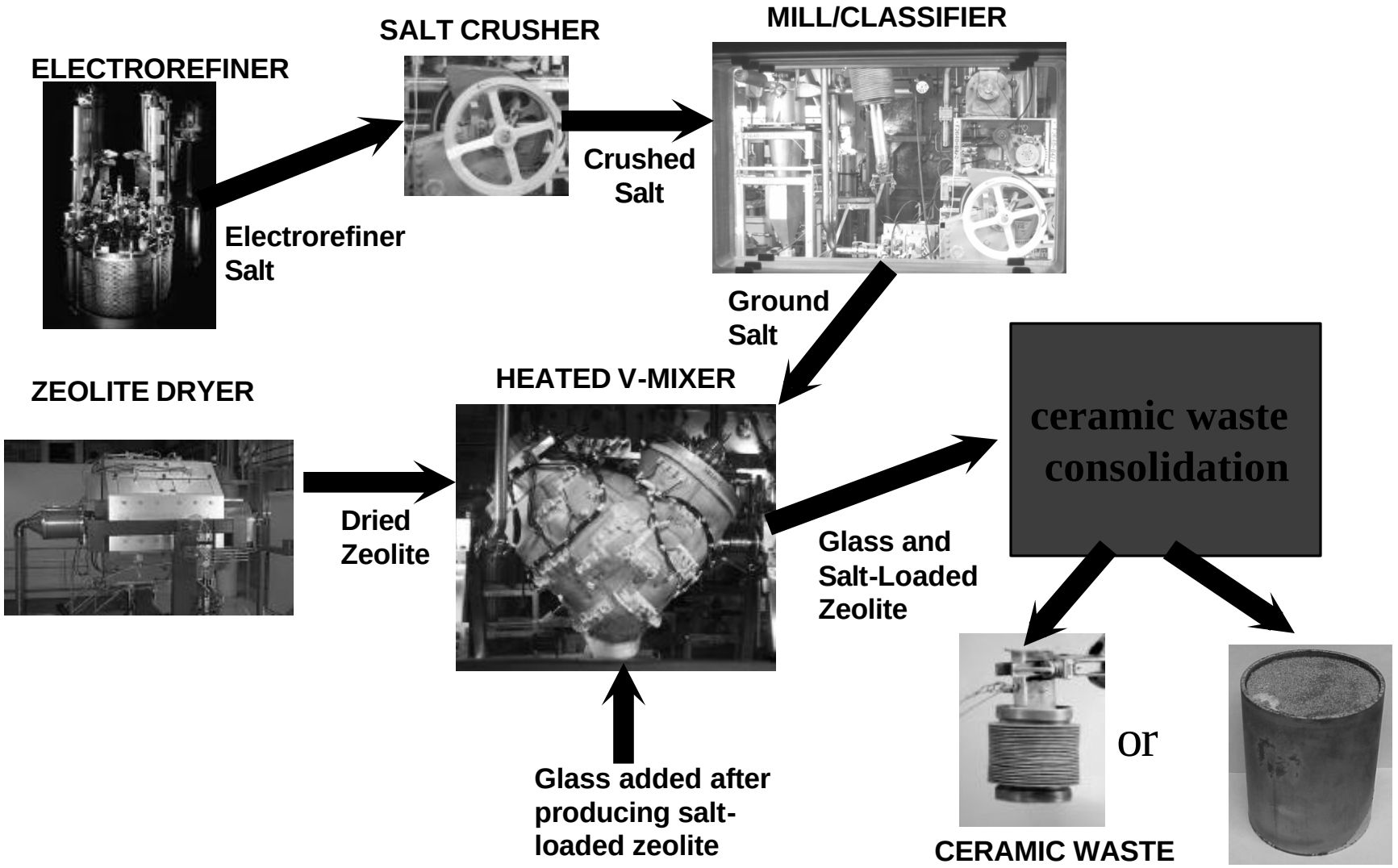
Ceramic Waste

- **The ceramic waste form is a zeolite-based, glass-bonded ceramic.**
  - Zeolites have cages in which salt molecules can be occluded.
  - Cations are available for ion exchange with fission products.
- **The electrorefiner salts containing the active metal fission products (alkali, alkaline earth, and rare earth) and transuranics are loaded into zeolite A.**
- **The salt loaded zeolite A converts to sodalite when processed at 800 - 925°C.**

Unit Cell of Zeolite A :
$Na_{12}[(AlO_2)_{12}\ (SiO_2)_{12}]$

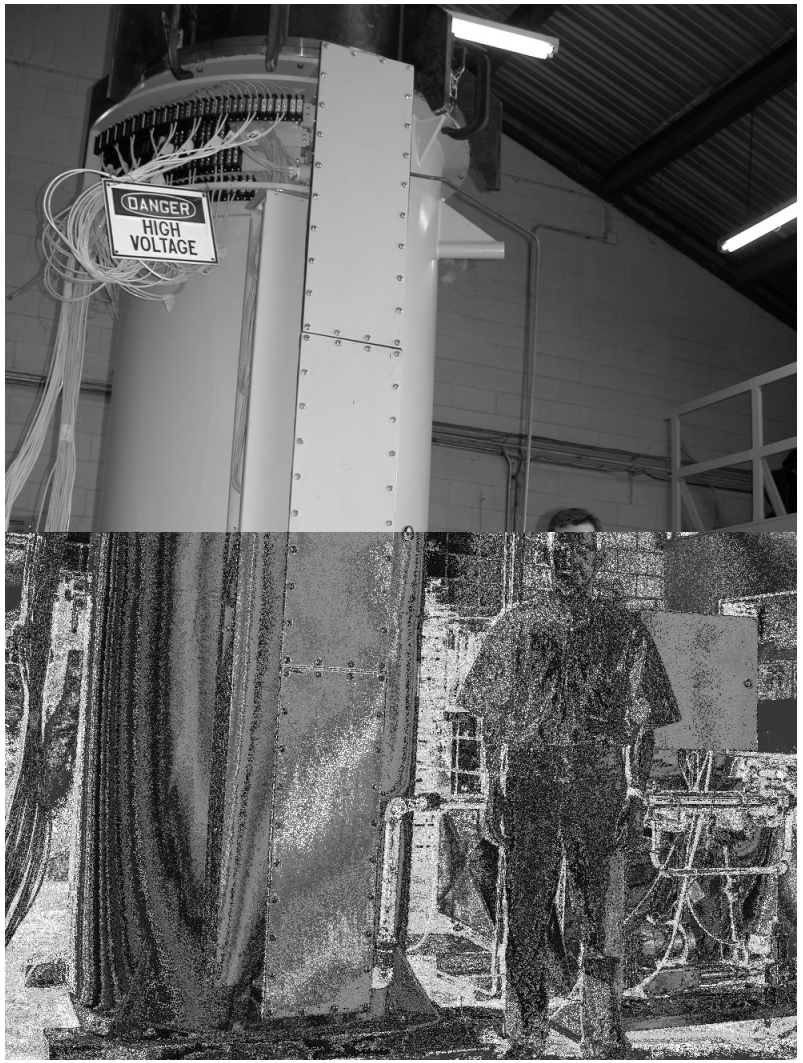


Ceramic Waste Process



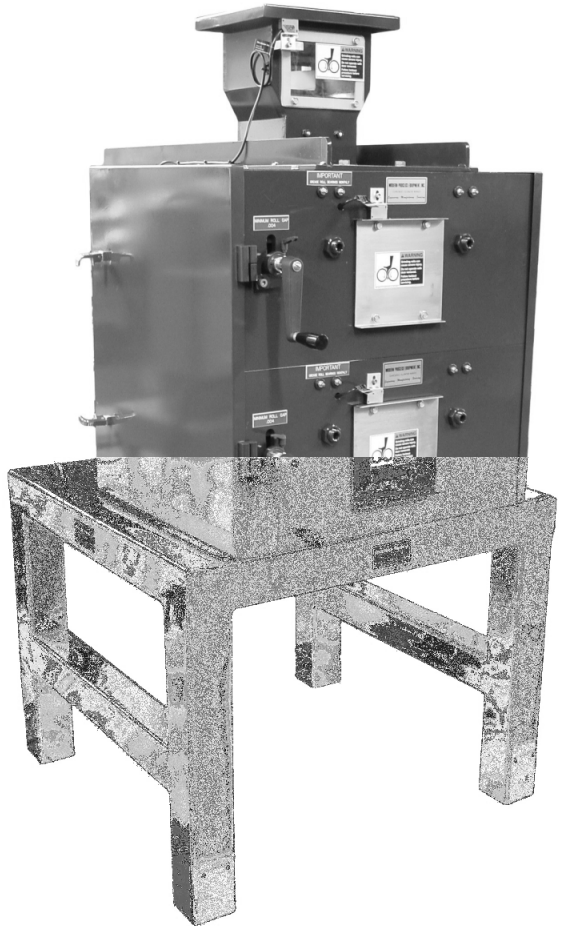
Ceramic Waste Form Development and Implementation

- **Production furnace was procured from Keith Company this summer.**
- **Furnace characteristics are:**
  - Maximum operating temperature of 1025 ˚C
  - Internal diameter of 0.6 m (2 ft)
  - Length of 3 m (10 ft)
- **Furnace is capable of processing waste forms in excess of 320 kg.**
- **Furnace is now being readied for installation and testing out-of-cell.**



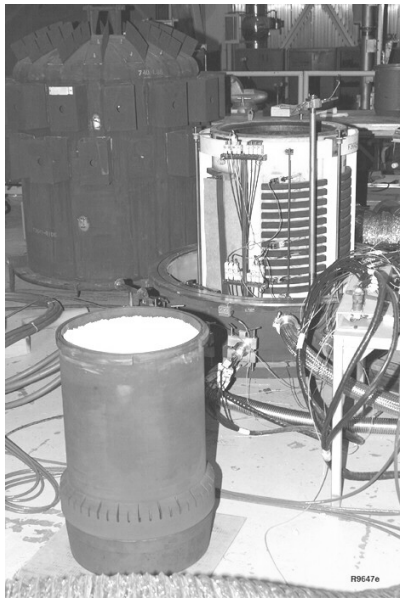
Production Scale Zeolite Grinder

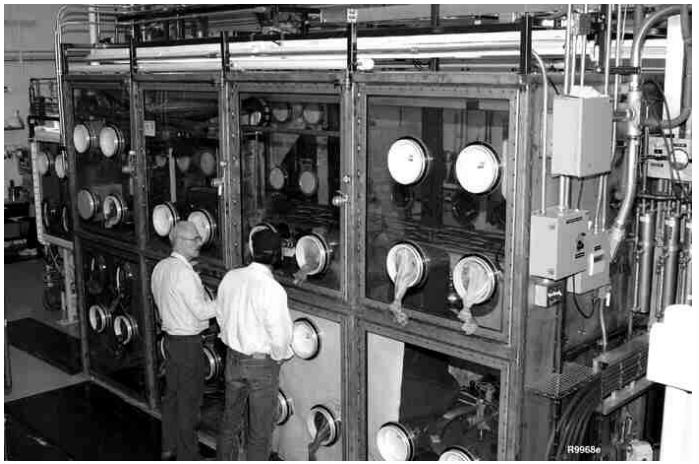
- **Zeolite grinder is needed for processing raw zeolite into the appropriate particle size.**
- **Grinder is being obtained from Modern Process Equipment.**
- **Grinder characteristics are:**
  - Constructed with corrosion resistant materials (can grind salt and zeolite)
  - Grind 50 kg of zeolite per hour (minimum)
  - Produces final particle size of 45-250 μm



Metal Waste Development Activities

- **The Prototype Metal Waste Furnace is installed in a large glovebox in the Fuel Assembly and Storage Building.**
- **A series of test runs were completed to show equivalency of the Prototype to the Production Metal Waste Furnace in mockup.**
- **The Prototype furnace is being used to**
  - Finalize the full-scale MW production process (=90 kg) which will be used in cell
  - Demonstrate the reliability of each process step, including sodium oxidation, salt distillation, and ingot formation prior to installation of the Production Furnace in HFEF
  - Validate acceptability of the produced ingots through 5 qualification runs





Waste Form Qualification

- **Waste forms are being extensively characterized for qualification.**
- **Waste form degradation models are being developed for each waste form.**
- **ANL is performing repository performance assessment calculations to assess the impact of the waste forms on the repository.**
- **ANL is working within the high-level waste community to gain acceptance of the waste forms.**
- **Report prepared for Congress addressing the disposal of the waste forms.**
  - DOE-NE, DOE-RW (Office of Civilian and Radioactive Waste Management), and DOE-EM (Environmental Management) concurred on disposal plans.
- **ANL waste forms are now classified formally as high-level wastes in DOE orders.**

HLW Data Package

A data package was compiled for the ceramic and metal waste forms. This document included 71 reports containing data and analyses needed to support acceptance into Yucca Mountain. Issues addressed in the reports include:

- waste form specifications
- waste form characteristics and degradation data,
- production information
- radiation effects
- product consistency
- impact of processing (HIP vs. PC) on waste characteristics
- leach behavior
- radionuclide distribution
- modeling of degradation behavior

Summary

- The production treatment of EBR-II fuel for disposal has been on going since September 1990. More than 3 MTHM of fuel have been treated.
- Focus for FY04 was on technology development and treatment of driver fuel.
- Sodium Evaporation - MEDEC process was successfully applied to 3 different blanket fuels from both Fermi-1 and EBR-II reactors. Evaluation of MEDEC continuing.
- High Throughput Electrorefining - Prototype PEER will be used to demonstrate concept feasibility and to develop operating conditions. PEER concept could be used to increase blanket fuel processing throughput and decrease cost and duration of EBR-II blanket fuel treatment.

Summary

- **Waste form qualification activities have progressed to an advanced stage.**
- **Production waste equipment is being readied for operations.**
- **Technology development and demonstrations continue to be a major program focus.**